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Bell Lake Dam,
Harrison, Montana,
Madison County,
MT-834

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

BELL LAKE DAM
HARRISON, MONTANA
MADISON COUNTY
MT-834

PLEASE RETURN

PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

FARRELL AND RICE RANCHES
(OWNERS AND OPERATORS)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

APRIL 1980

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TABLE OF CONTENTS

Paragraph — Page

EXECUTIVE SUMMARY iv
PERTINENT DATA. vii

CHAPTER 1 - BACKGROUND

1.1 INTRODUCTION. 1
  1.1.1 Authority and Scope. 1
  1.1.2 Purpose. 2
  1.1.3 Inspection 2

1.2 DESCRIPTION OF PROJECT. 3
  1.2.1 General. 3
  1.2.2 Regional Geology and Seismicity. 4
  1.2.3 Site Geology 4
  1.2.4 Design and Construction History. 5

CHAPTER 2 - INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES 6
  2.1.1 Spillway 6
  2.1.2 Outlet 7
  2.1.3 Freeboard. 7

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY. 8
  2.2.1 General. 8
  2.2.2 Reservoir Storage and Spillway Discharge . . . 8
  2.2.3 Preliminary Probable Maximum Flood 8
  2.2.4 Flood Routing. 9

2.3 GEOTECHNICAL EVALUATION 9
  2.3.1 Dam Embankment 9
  2.3.2 Foundation Conditions, Seepage, and Drainage 11
  2.3.3 Stability. 12

2.4 PROJECT OPERATION AND MAINTENANCE 12
  2.4.1 General 12
  2.4.2 Dam 12
  2.4.3 Reservoir. 13
  2.4.4 Warning System 13

TABLE OF CONTENTS (Cont.)

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS 14
3.1.1 Size, Hazard Classification, and Safety Evaluation 14
3.1.2 Embankment Dam 14
3.1.3 Spillway and Reservoir Capacity 15
3.1.4 Outlet Works 15
3.1.5 Operation and Maintenance 15

3.2 RECOMMENDATIONS 16

REFERENCES 18

APPENDIX 19
Correspondence

PHOTOS
(Bound at End of Text)

1 View toward dam, dam site on left just beyond ridge in background
2 Spillway, right abutment
3 Riprap on left spillway slope
4 Outlet works slide gate control
5 Outlet works conduit exit
6 Downstream slope
7 Upstream slope
8 Longitudinal crack on dam crest along upstream edge

PLATES

1 Vicinity
2 Site plan
3 Spillway plan and profile
4 Spillway rating curve
5 Outlet works profile
6 Dam embankment sections
7 Dam embankment profile

EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation (DNRC), and the Farrell and Rice Ranches, CH2M HILL inspected Bell Lake Dam on July 16, 1979, under the authority of Public Law 92-367. The dam is located on a tributary of South Willow Creek in Madison County, about 15 miles southwest of Harrison, Montana.

This report was compiled from information obtained during an onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Bell Lake Dam is owned and operated by the Farrell and Rice Ranches. The dam and reservoir are located on public land administered by the U.S. Forest Service. Bell Lake Dam is used for the storage of irrigation water. Use of National Forest land for such purposes is through Special Use Permits issued by the U.S. Forest Service.

The 20-foot-high earth dam will impound 590 acre-feet of water at assumed top of dam, elevation 8800 feet National Geodetic Vertical Datum (NGVD), previously Mean Sea Level (MSL). On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is small in size. The dam is located such that its failure could endanger many lives at a downstream campground. However, no dam breach analysis or routing of a dam breach flood was made for the downstream area and the conclusions on probable damage are based on a brief field visit and engineering judgment.

The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that a small-sized project with a high downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of one-half to the full probable maximum flood (PMF). The SDF is intended to represent the largest flood that need be considered in the evaluation of a project. Because of the limited downstream hazard potential, we recommend this project safely control a spillway design flood of one-half the PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated PMF was developed for the 1.1-square-mile drainage basin. Refinement of this estimate may either increase or decrease the final flood characteristics. The estimated PMF resulting from the 72-hour general storm has a volume of 1,080 acre-feet and a peak flow of 11,300 c.f.s. The spillway has a maximum discharge capacity of 550 c.f.s. with the reservoir at assumed top of dam, elevation 8800 feet NGVD. Routing of the estimated PMF was started with the reservoir at spillway crest, elevation 8795.4 feet NGVD. Routing indicates that the dam is overtopped by a flood having 35 percent of the PMF ordinates, which is about 70 percent of the recommended spillway design flood. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such failure could endanger many lives in the campground located approximately 5.5 miles downstream of the dam.

On the basis of the field inspection and preliminary hydrologic analysis, Bell Lake Dam does not now conform to inspection guidelines with respect to discharge and/or storage capacities for safely handling the recommended spillway design flood.

The spillway log boom diameter is too small to effectively trap floating debris, and it could easily break under normal loadings. Spillway riprap downstream of the dam axis could be removed by high discharges, and subsequent erosion and failure of the embankment could occur. The top of the outlet works wet well is below spillway elevation and could become blocked by debris. The gate stem is very rusty, and the headwall at the discharge end of the outlet conduit showed heavy spalling of concrete. The conduit was blocked approximately 50 percent by rock that had fallen into the discharge channel. Neither the intake structure nor the conduit could be inspected at the time of the field visit. The upstream slope has experienced some movement, as evidenced by a small crack along the crest. The outlet channel slopes below the dam toe are steep and rocks have fallen into the channel, restricting flow.

RECOMMENDATIONS

Develop and place in operation a downstream warning system, for use in the event of possible dam overtopping or structural failure. Inspect the entire length of the outlet conduit and repair as required. Clear the rock blockage from the discharge end of outlet conduit and extend the outlet to the end of channel, backfilling channel with gravel filter and rock. Construct a trashrack for the intake structure if one does not exist already. Extend gate wet well at least to dam crest and fit with safe cover. Refurbish gate stem to ease operation and to prevent further corrosion. Rebuild log boom. Inspect upstream slope when reservoir is drawn

down to determine nature of slope movement. Remove the trees, brush, and debris on and around the downstream slope of the dam.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate. Conduct a stability analysis of the embankment for seismic and static loading conditions with appropriate field and laboratory data. Conduct periodic dam inspections at intervals not to exceed 5 years, by engineers experienced in dam design and construction.

MONTANA
RICHARD L
FOSTER
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REGISTERED
PROFESSIONAL ENGINEER

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. General

Federal I.D. No.	MT-834
Owner	Farrell and Rice Ranches
Operator	Farrell and Rice Ranches
Date Constructed	Original, 1931 Reconstruction, 1957
Purpose	Irrigation
Location	Section 32, T3S, R3W principal meridian, Madison County, Montana
Watershed	Headwaters South Willow Creek, a tributary of the Jefferson River
USGS Quadrangle	Waterloo
Downstream Hazard	Category 1 (High)

2. Reservoir

Elevation at Normal Pool	8795.4 feet NGVD
Surface Area at Normal Pool	30 acres
Drainage Area	1.1 square mile
Normal Storage at Spillway Crest (Elevation 8795.4 feet NGVD)	450 acre-feet
Maximum Storage at Dam Crest (Elevation 8800.0 feet NGVD)	590 acre-feet
Surcharge Storage	140 acre-feet

3. Spillway

Location	Right abutment
Type	Uncontrolled chute
Width	15 feet
Length	90 feet
Entrance Elevation	8795.4 feet NGVD
Capacity (Reservoir at Dam Crest)	550 c.f.s.

4. Outlet Works

Discharge Conduit	24-inch, concrete-encased CMP
Length	160 feet
Gates	Mid-slope upstream face of dam, 24-inch-diameter slide gate in wet well
Capacity (Reservoir At Dam Crest)	30 c.f.s.

5. Dam

Type	Rolled earth
Length	120 feet
Crest Width	20 feet
Crest Elevation	8800 feet NGVD (assumed)
Hydraulic Height (Crest to Toe)	20 feet
Upstream Slope	1 V on 2 H
Downstream Slope	1 V on 2 H above berm 1 V on 1.5 H, typical below berm 1 V on 0.7 H at outlet

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Bell Lake Dam, which is owned by Farrell and Rice Ranches.

The National Dam Inspection Act, Public Law 92-367, dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations, and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) A limited investigation to assess the general safety condition of the dam.

(2) Based upon an evaluation of the available data and a visual inspection.

(3) Performed to determine whether any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.

(4) Not intended to include extensive explorations or analysis, or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in

Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations, with the exception of extreme emergency situations. In these cases, the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementing these Phase I recommendations rests with the dam owner and the State of Montana. Before any action to implement report recommendations, the owner is urged to contact the State of Montana DNRC. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of this inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project, a detailed review of available plans and specifications, and design analyses. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

Captain Don Warner, Engineer, U.S. Army Corps of Engineers

Art Taylor, State of Montana, Department of Natural Resources and Conservation

Barry Rice, Farrell and Rice Ranches

CH2M HILL personnel who participated in the field inspection and contributed to this report are:

Miles C. Bubenik, Geotechnical Engineer, Team Leader

Jerry Jacksha, Geotechnical Engineer

Loren Bottorff, Hydrologist/Hydraulics Engineer

This report has been reviewed by the following owners and agencies and their comments are attached in the Appendix.

State of Montana, Department of Natural Resources and Conservation

Farrell and Rice Ranches, Representatives and Owners

U.S. Forest Service

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Bell Lake Dam and Reservoir are located at the headwaters of South Willow Creek, a tributary of Jefferson River, in Madison County, Montana, approximately 15 miles southwest of the town of Harrison (see Plate 1). The dam is 20 feet high and impounds approximately 590 acre-feet at the dam crest. According to information received from the U.S. Forest Service, as many as 75 to 150 campers use the Potosi campground on selected weekends during July through Labor Day. In addition, the Forest Service estimates 200-300 campers use campsites above and below the Potosi campground during the same time of the year. Based on a visual reconnaissance and engineering judgment, many lives in the downstream Potosi campground could be affected by a sudden breach of the dam. On the basis of this information and in accordance with the recommended guidelines, the project size is small and the downstream hazard potential is high (Category 1).

Principal use of the 30-acre reservoir is irrigation storage. The project is owned, operated, and maintained by Farrell and Rice Ranches.

The 90-foot-long spillway channel is located on the right abutment, shown on Plate 2. A 24-inch CMP outlet with a 24-inch-diameter slide gate and gate controls at the dam crest is used for irrigation releases.

1.2.2 Regional Geology and Seismicity

The geology and seismicity of the Bell Lake Dam and Reservoir area were addressed in a memorandum by R. D. Eckerlin (Ref. 2). The following information is taken from that memorandum.

> Bell Lake Dam is located on a tributary to South Willow Creek, which is situated in the central part of the Tobacco Root Mountains within the Northern Rocky Mountains physiographic province. The Tobacco Root Mountains are rugged and composed mostly of Precambrian igneous and metamorphic rocks that have been dissected by stream erosion and modified by alpine glaciation. Cretaceous granite, comprising the Tobacco Root Batholith, intruded the center of these mountains while they were rising about 70 million years ago. The Tobacco Root Batholith, occupying approximately 100 square miles, is elongate in the northwest direction. Bell Lake Dam lies within the batholith about one-half mile northeast of the batholithic contact with Precambrian crystalline gneisses and schists. This part of the batholith is composed of quartz diorite. Evidence of Pleistocene alpine glaciation can be seen in the region in the form of cirques, moraines, and outwash terraces extending down the valleys. Bell Lake is situated within a glacial cirque perched high on the northeastern slope of Thompson Peak.
>
> In accordance with the recommended guidelines' seismic zone map (Ref. 1), the site is in seismic zone 3, which has a potential for major earthquake damage. Although the zone map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site. A Modified Mercalli Intensity of VIII or greater is expected to occur repeatedly during any 100-year time. Algermissen (Ref. 3) estimates a 90 percent probability that between 20 and 42 percent of gravity acceleration will occur in any 50-year period. An estimate of the acceleration from the 1959 Hebgen Lake earthquake at Bell Lake is 0.1 g.

1.2.3 Site Geology

There is no geologic report or subsurface information on file for this site. Brief construction sketches suggest

that the dam is founded approximately 6 feet above bedrock. Material overlying the bedrock is glacial deposits consisting of silts, sands, and gravels. The left abutment is composed of a fractured, weathered gneiss. The right abutment is the spillway, which has been cut into a talus slope. Available information states that the spillway base is very near the granite bedrock. The 24-inch-diameter outlet was placed on the glacial sediments recorded to be about 6 feet thick.

Downstream of the dam, the canyon is steep and narrow (Photo 1), with a gradient of 700 feet per mile for approximately 3 miles, where the drainage flows into South Willow Creek Canyon, which is broader and somewhat flatter, with a gradient of 200 feet per mile. South Willow Creek leaves the mountain canyon 12 miles below the dam and flows into a wide valley.

1.2.4 Design and Construction History

Original construction at the Bell Lake Dam was prior to 1931, as stated by F. E. Thieme in his August 18, 1942, memo (Ref. 6). Attached to the memo are a sketch of the then existing structure and recommendations for structural modifications that were ultimately constructed in about 1957. A single drawing dated 1956, incorporating sketches prepared by Thieme in 1942, was developed by the Soil Conservation Service. The few specifications for the 1957 reconstruction are noted on the drawings.

Thieme's 1942 memo mentions seepage near the outlet pipe and measured flow to be 1.25 cubic feet per second (562 g.p.m).

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Bell Lake Dam is located between natural ground and the dam embankment at the right abutment. The spillway consists of an unlined chute (Photo 2) of rock and earth. The entrance to the chute is about 45 feet wide and is 4.6 feet lower than the low point on the dam crest. Within a distance of 45 feet the chute gradually narrows to a width of 15 feet at the dam axis. This trapezoidal section, with a 1 V on 1 H side slope on the right and a 1 V on 1.5 H on the left slope, acts as the control section for spillway discharges. Downstream of this section, the chute invert drops about 2.5 feet in a distance of 45 feet and then enters a series of riffles and drops that are well removed from the dam. The spillway plan and profile are shown on Plate 2.

At the chute entrance, a series of logs are tied together with cable to function as a log boom (Photo 2). The log on the right (looking downstream) is too small in diameter (4 to 8 inches) to effectively trap floating debris, and it could easily break under normal loadings. The dam embankment is riprapped along the spillway chute with rock that is 12 inches or more in diameter. This riprap is adequate from the chute entrance to the dam axis, but the riprap size downstream of the dam axis (Photo 3) appears inadequate for anticipated velocities and could be displaced by high discharges. Subsequent erosion and failure of the embankment could occur. The spillway discharges are not well confined to a safe distance downstream of the dam. At the time of the inspection, water was spilling from the chute. High spillway discharges would spill from the chute that is nearer the embankment and could erode the downstream face of the dam.

The spillway rating was developed by assuming that critical depth occurs in the 15-foot-wide chute section at the dam axis. Backwater computations were computed in the approach channel with a Manning's "n" of 0.025 for the chute floor and 0.035 for the side slopes. The maximum discharge capacity of the spillway, with the reservoir at assumed top of dam, elevation 8800 feet NGVD, was estimated to be 550 c.f.s. The discharge rating curve is presented on Plate 4.

2.1.2 Outlet

The outlet works for Bell Lake Dam is located through the embankment near the center of the dam. The intake structure could not be inspected because of the reservoir level, and it is unknown whether a trashrack is present. The 24-inch corrugated metal pipe (CMP) is about 160 feet long (profile is on Plate 5). A 24-inch-diameter slide gate is located in a wet well about 115 feet downstream from the conduit intake. The top of the wet well is about 0.5 foot lower in elevation than the entrance to the spillway. At the time of the inspection, the top of the wet well was 0.8 foot below the reservoir water surface elevation.

The top of the wet well was covered by old boards weighted down by rocks. This arrangement could collapse and plug the outlet conduit. The control for the gate is reached by a scaffolding (Photo 4) of poles from the crest of the dam. The gate wheel and stem are exposed to the weather and are very rusty. The gate wheel was chained and locked in the closed position; the operator was unable to unlock and open it at the time of the inspection.

There is no outlet structure except a concrete headwall, which shows heavy spalling. Rock is stacked along the discharge channel for a distance of about 30 feet downstream of the conduit. Some of this rock has fallen into the channel and blocks about one-half of the pipe opening (Photo 5). The conduit could not be inspected during the site inspection because of this blockage and the high water level. Previous inspection reports mention that the pipe is broken about 16 feet downstream of the entrance. However, a break at this location (upstream of the gate) is not critical but should be repaired.

The discharge rating for the outlet works was developed with the gate fully open. A Manning's "n" of 0.024 was used to estimate friction losses with the conduit flowing full. The rating was developed with the rock blockage at the outlet removed, but significant changes in discharge capacity do not occur if the blockage remains in place. The maximum discharge capacity of the outlet works, with the reservoir at the assumed top of dam, elevation 8800 feet NGVD, was estimated to be 30 c.f.s.

2.1.3 Freeboard

Because the dam overtops during the probable maximum flood (PMF: see paragraph 2.2.4), there is no freeboard. The vertical distance between the low point on the dam and the reservoir level during the inspection was 4.3 feet. The

spillway crest is 4.6 feet below the low point on the dam crest. The crest of the dam varies 1.1 feet over a 110-foot length. The effective fetch for wind-generated waves is less than 1,000 feet, and wave runup on the embankment is estimated to be less than 2 feet. Although the dam will overtop during the PMF, the vertical distance between the dam crest and the normal reservoir level is adequate to prevent overtopping the embankment by wind-generated waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is continental, characterized by warm summers, cold winters, and a semiarid precipitation regime. The nearest climatological station (elevation 4700 feet NGVD) is at Norris, about 15 miles east of the center of the basin. Mean annual precipitation at the station is 18.5 inches with 52 percent falling in April through July. Mean annual precipitation on the Bell Lake drainage basin is probably near 25 inches. Mean annual temperature at Norris is 47 degrees Fahrenheit (F); mean January temperature is 25.9 degrees F; and mean July temperature is 70.3 degrees F. Summer temperatures can exceed 100 degrees F, and winter temperatures can dip well below 0 degrees F. Winters have few extended cold spells; periods of warm, "chinook" winds occur between cold spells.

The drainage basin area for Bell Lake Dam is 1.1 square miles and roughly circular in shape. Basin elevations vary from 8800 feet at the dam to 10,382 feet on the western boundary. The basin is steep and rocky; only about 30 percent of the basin is forested. There are no well-defined inflow streams to the reservoir. There are no USGS stream gages in the basin or in surrounding basins.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 30 acres and a storage of 450 acre-feet at assumed spillway crest, elevation 8795.4 feet NGVD. Approximately 140 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The spillway discharge, with the reservoir at dam crest, is 550 c.f.s., or about 45 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The procedure contained in the U.S. Weather Bureau's Technical Paper 38 (Ref. 3) was used to compute the probable maximum precipitation (PMP). This storm produces 11 inches in 6 hours and 15.2 inches in 24 hours. The 72-hour precipitation was estimated to be 115 percent of the 24-hour precipitation value, or 17.5 inches.

The basin is very rocky and infiltration losses would be minimal during a major storm. However, frozen ground and no infiltration losses were assumed during the entire flood. A base flow of 15 c.f.s. was used for the entire flood.

Because the basin and time of concentration are very small, no unit hydrograph was developed. The 15-minute values of precipitation were converted directly to c.f.s. values as inflow to the reservoir for the 72-hour storm. This estimate of the PMP produced a flood with a peak flow of 11,300 c.f.s. and a volume of 1,080 acre-feet.

2.2.4 Flood Routing

The PMF was routed through the reservoir by using the computer program HEC-1 (Ref. 4). The reservoir level was assumed to be at the spillway crest at the beginning of the PMF.

Routing studies indicate:

a. During the full PMF, the dam would be overtopped when approximately 43 percent of the flood volume had entered the reservoir.

b. Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 35 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankment

The original earth dam was built at the present Bell Lake Dam site prior to 1931. There is no information on the original dam construction except for a cross section showing embankment dimensions. The original dam embankment was incorporated into the present dam, as shown in Plate 6. The existing Bell Lake Dam appears to be built out of a gravelly,

sandy silt. This material would be highly erodible if the dam were overtopped. The material does not appear to be subject to liquefaction because of seismic shock.

The present dam has a 20-foot crest width and is 120 feet long. The upstream slope is 1 V on 2 H, and the downstream slope varies from 1 V on 2 H above the berm (elevation 8797 feet NGVD) to approximately 1 V on 1.5 H in the lower portion (original dam). Above the outlet headwall, the downstream slope is very steep, being 1 V on 0.7 H. A cutoff trench was excavated beneath the upstream embankment. It is very likely that the upstream addition and the original dam were placed near the original ground surface. Comments in a memorandum dated 1942 (Ref. 6) indicate that the underlying rock surface is about 6 feet below original ground surface.

There are no construction records available that describe the methods used to construct the original and the revised dam embankments. The SCS plan, dated 1956, stated that the borrow material for the embankment came from an existing hillside pit near the south end (right abutment). Material was to be well compacted at a moisture content range of 14 to 17 percent, with maximum size rock of 4-inch diameter.

Visual inspection showed the downstream slope was covered with a thin layer of 12-inch-minus rock and some small pine trees, brush, and a debris pile near the right abutment (Photo 6). The upstream slope was covered with 3-foot-minus riprap. It appears that the riprap was placed without bedding and directly on the embankment slope (Photo 7).

There was a longitudinal crack in the embankment material on the dam crest along the upstream slope edge between the middle of the dam and the outlet gate tower (Photo 8). With the reservoir level at normal pool, most of the upstream slope could not be inspected for slumps or slides that may have caused the crack. The exposed slope did not show any irregularities. When the reservoir is drawn down, the upstream slope should be inspected to evaluate the nature of the movement. Our judgment is that this existing condition does not warrant an emergency lowering of the reservoir. However, an inspection should be made during the next low water.

All available information indicates that the 24-inch outlet conduit is encased in concrete and both it and the gate well are founded near the original ground surface in the native, gravelly, sandy silt. One previous inspection report, December 1963 (Ref. 7), indicated that the outlet conduit pulled apart at a joint upstream from the embankment (see Plate 5). This specific occurrence should not affect the

embankment stability. The condition of the conduit beneath the embankment is unknown.

The right edge of the dam embankment also serves as the left side slope for the spillway (Plate 7). Although the slope is covered with 12-inch-minus rock (Photo 3), severe slope erosion would take place under high sustained spillway discharges. This erosion would adversely affect dam stability as flow would erode the dam embankment. Additional coverage of the slope with larger riprap or other slope protection is required.

A talus slope forms the right side of the spillway. In the past, some large rock has moved down the slope. At the time of the inspection, the talus slope appeared to be stable and covered with vegetation above the spillway area. Inspections of the slope should be made in the spring of the year, to check for large rock that could be dislodged and move into the spillway, possibly causing enough blockage to result in dam overtopping.

2.3.2 Foundation Conditions, Seepage, Drainage

The dam embankment spans a narrow gorge with exposed bedrock on the left abutment and bedrock underlying the spillway on the right abutment. The right side of the spillway is formed by a rock talus slope. Available information indicates that no special treatment of the abutment surfaces was done before placing embankment fill.

A description of the foundation preparation is not available for either the original dam or the embankment addition. Available data indicate the present dam is founded on a glacial deposit of gravelly, sandy silt. Plate 6 shows an upstream cutoff trench; however, it indicates the trench extends to the base of the gate well, which may be 6 feet above bedrock, as suggested in an August 1939 memorandum (Ref. 8).

During the July 16, 1979, inspection, when the reservoir was slightly above the spillway crest, no seepage or erosion from past seepage was observed on the embankment or abutment contacts. At the outlet conduit exit, channel seepage was present on the right side of the outlet pipe between the headwall and riprapped slope (2 to 3 gpm) and 8 feet downstream at the base of the left slope (5 to 10 gpm). The seepage was flowing clear. The source of the seepage is probably the reservoir, and it does not appear to affect embankment stability.

The dam embankment contains no known internal drains or piezometers.

2.3.3 Stability

For the existing Bell Lake Dam, there is no information on embankment strength parameters or internal water levels, and there is no known stability analysis on file.

The side slopes of the low-level outlet channel do not appear stable. Some of the hand-placed rock lining along the slope has fallen into the channel, blocking flow from the outlet pipe. In addition, the embankment slope above the outlet headwall is constructed on a 1 V on 0.7 H slope that (in our judgment, based on the embankment material) will not conform to the guideline requirements for slope stability.

The presence of a 1/2-inch-wide, 50-foot-long, semicircular crack along the upstream embankment crest near the outlet works indicates that a portion of the upstream slope is unstable. Because of the high reservoir level, an inspection to evaluate the nature of the movement was not possible. It cannot be determined at this time whether movement was caused by oversteepening (caused by erosion from wave action) or some other mechanism.

Because of the crack along the upstream embankment crest, and the oversteepened embankment slope at the outlet works exit, it is our judgment that Bell Lake Dam does not conform to embankment stability requirements in the recommended guidelines.

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

The facility is owned and operated by the Farrell and Rice Ranches. Information on operations and maintenance was obtained from a discussion with Mr. Barry Rice.

2.4.2 Dam

The dam appeared to lack recent maintenance. Logs have collected along the upstream face of the dam; the outlet gate, wheel, and stem were very rusty; and the discharge end of the outlet conduit was partially blocked by rock. However, a September 26, 1978, inspection report by the U.S. Forest Service indicates that considerable work had been done since its 1977 inspection, and maintenance is continuing. Work required, as noted by the Forest Service, included debris

cleanup, repair of gate stem corrosion, and removal of trees on the downstream slope. Corrosion of gate stem and trees on the embankment were also noted during our July 16, 1979, inspection.

The U.S. Forest Service conducts annual inspections of the facility and makes appropriate recommendations for maintenance and repairs. The dam usually is visited by the owners only during a short period in the summer when the outlet gate is open.

2.4.3 Reservoir

Water from Bell Lake is used for irrigation. According to Mr. Rice, the gate normally is opened for about 3 weeks at the end of July. The owners file an operation and maintenance plan each year with the U.S. Forest Service. The 1978 and 1979 plans call for inspection and/or repair of the dam and appurtenances on or before July 1. The plan says that proposed drawdown starts on July 20, the headgate is fully open on August 10, and the headgate is closed November 15. The reservoir is refilled each spring by snowmelt and the spillway operates until drawdown begins.

2.4.4 Warning System

There is no formal warning plan for use in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 Findings

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, Bell Lake Dam is small in size, with a high downstream hazard potential rating. The recommended spillway design flood for this project is one-half the full PMF. The project can safely control only 35 percent of the PMF, which is about 70 percent of the spillway design flood, without overtopping and causing the dam to fail. Because Bell Lake Dam cannot safely control one-half the PMF, the project does not meet inspection guidelines.

3.1.2 Embankment Dam

A visual inspection of the dam embankment revealed no transverse cracking, slumps, or any embankment or abutment seepage. A longitudinal crack was observed near the outlet works and along the upstream edge of the crest; it appears to have been the result of movement of the upstream slope. The cause of the movement needs to be determined as soon as the reservoir level is lowered and the upstream slope is exposed. Seepage was observed at the outlet works conduit exit and several feet downstream in the discharge channel. This seepage should not affect embankment stability.

The exposed upstream slope (above the normal reservoir level) and downstream slope were uniform with no irregularities or slumps. The downstream slope supports a sparse covering of small brush. Riprap on the upstream slope adequately protects against erosion, and the normal freeboard is adequate to prevent wind-generated waves from overtopping the dam crest.

No stability analysis of the dam embankment is on file. No gradation or strength tests of the various materials actually used in embankment construction are available for review. In our judgment, embankment stability does not conform to the recommended guidelines.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of about 30 acres and a storage of 450 acre-feet at assumed spillway crest, elevation 8795.4 feet NGVD. Approximately 140 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The discharge of the spillway, with the reservoir at the dam crest, is 550 c.f.s. Spillway discharges less than this maximum flow could leave the channel and cause erosion along the dam toe. Also, riprap downstream of the dam axis could be removed by high discharges. Subsequent erosion and failure of the embankment could occur. The log boom is too small in diameter to effectively trap floating debris, and it could easily break under normal loadings.

3.1.4 Outlet Works

The intake structure and the conduit could not be inspected during the site visit. The gate wheel and stem are exposed to the weather and are very rusty. The gate wheel was chained and locked in the closed position, and the operator was unable to open the lock at the time of the inspection. The headwall at the discharge end of the outlet conduit shows heavy concrete spalling. Some rock that was stacked along the discharge channel has fallen into the channel and now blocks about one-half of the pipe opening. The top of the gate well is below spillway crest elevation and could become blocked by debris.

3.1.5 Operation and Maintenance

The U.S. Forest Service conducts annual inspections of the facility and makes appropriate recommendations for maintenance and repairs. The Farrell and Rice Ranches are responsible for operation and maintenance. According to previous inspection reports, a considerable amount of work has been accomplished on the dam in the last few years, but a few areas show a lack of recent maintenance. Logs have collected along the upstream face of the dam. The outlet gate wheel and stem were very rusty, and the discharge end of the outlet conduit was partially blocked by rock. The reservoir is operated to store irrigation water, and the gate usually is opened for about 3 weeks at the end of July. The reservoir is refilled each spring by snowmelt, and the spillway operates until drawdown begins. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

For the present project, storage between normal pool and dam crest provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety without decreasing this flood protection.

The findings suggest that high priority be given the following recommendations:

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending dam overtopping or structural failure.

2. Inspect the entire length of outlet conduit and repair as required.

3. Clear rock blockage from the discharge end of outlet conduit.

4. Construct a trashrack for the intake structure if it does not already exist.

5. Extend gate wet well at least to the dam crest and fit with a safe cover.

6. Refurbish gate stem to ease operation and to prevent further corrosion.

7. Rebuild log boom using logs the size of the largest logs observed along the reservoir shore. The ends of the boom should be positioned so the boom functions for all reservoir levels.

8. Provide additional riprap or other type of slope protection to prevent embankment erosion for all spillway discharges.

9. Extend outlet conduit to create a uniform downstream slope and backfill with gravel and rock designed to act as filter.

10. As soon as drawdown of the reservoir occurs, a qualified geotechnical engineer should inspect the upstream slope to determine the nature of the movement related to the crack on the dam crest and evaluate the effects on the overall embankment section.

11. Remove the trees and brush on the downstream slope and the debris pile near the right abutment. Backfill and compact all root holes.

12. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate.

13. Conduct, and place on file, stability and seepage analyses of the dam embankment. These analyses must be performed by a qualified geotechnical engineer and be based on: static and appropriate seismic loading conditions; in situ strength properties of the embankment, foundation, and abutment materials; and phreatic surface conditions. The material strength properties must be established by drilling and sampling with laboratory testing as appropriate, and the phreatic surface obtained by installing and monitoring piezometers.

14. Conduct periodic inspections of Bell Lake Dam at intervals not to exceed 5 years by engineers experienced in dam design and construction.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. Eckerlin, Richard D., U.S. Army Corps of Engineers, Memorandum on Bell Lake Regional Geology, August 16, 1979.

3. Algermissen, S.T. and Perkins, D.M., "A Probabilistic Estimate of Maximum Accelerations in Rock in the Contiguous United States," Bulletin, U.S. Department of the Interior, open file report, U.S. Geological Survey, No. 76-416, 1976.

4. U.S. Weather Bureau, Technical Paper 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Washington, D.C., 1960.

5. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.

6. Thieme, F.E., Assistant Regional Forester, "Letter to Union Central Life Insurance Company (Bell Lake Dam Owner), September 29, 1942.

7. Sorenson, Gordon E., U.S. Forest Service, "Dam Inspection Report," December 18, 1963.

8. Byrne, Office of Engineering, U.S. Forest Service, "Memorandum for L--H.H. Gurley," August 29, 1979.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR
32 SOUTH EWING
STATE OF MONTANA
(406) 449-2872
HELENA, MONTANA 59601

March 4, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Attn: Ralph Morrison

Re: CH_2M Hill Dam Safety Inspection Report on Bell Lake Dam
(MT-834).

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report. We offer the following comments:

On page ii and iii, the Spillway Design Flood (SDF) for the project should be one-half the full PMF. The dam can safely control 35 percent of the full PMF ordinates. It should be brought out in this report that this is about 70 percent of the SDF. This should be brought out on page 16, paragraph 2.2.4, and page 25, paragraph 3.1.1.

On page 18, a comment is made about small trees on the downstream face of the dam. The recommendations in the Executive Summary and Section 3.2 Recommendations should recommend removal.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Bell Lake Dam.

Sincerely,

Richard L Bondy

Richard L. Bondy, Chief
Engineering Bureau
(406) 449-2864

RB:AT:mb

"AN EQUAL OPPORTUNITY EMPLOYER"

Rice Ranches
BOB RICE AND SONS
Box 201 Phone 685-3367
Harrison, Montana 59735

February 27, 1980

Department Of The Army
Seattle District, Corps Of Engineers
Sidney Knutson, P.E.
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson,
Please consider my comments on the Norwegian Creek Dam and the Bell Lake Dam.

Norwegian Creek : The railroad trestle which you consider as being in grave danger in case of flooding is owned by Rice Ranches, and is in the process of being dismantled. The railroad tracks had been removed before your men inspected the dam. The highway bridge in this area has a large opening and is located on very level ground. Very little water has ever ran over the dam spillway. The oldest people in our valley cannot ever remember flood conditions comparable with the proportions that this survey indicate. Most of the creek area below the dam is owned or leased by Rice Ranches. Over 4½ miles of Norwegian Creek below the reservoir is flat and brushy with swamp area which would retain much of the run-off if dam were ever to fail. I do not agree with this report.

Bell Lake: If this dam were to fail, very little of the water would leave, because of the manner that it is constructed with so many rock in the area. I do not agree that this dam would wash away fast as the report implies. There is very little floating debree in the area and what there is is small in size and would not hinder the spillway. There is so much solid rock in rip-rap below the dam, that it could not move as stated in report. I feel that if the dam broke, the discharge would be so slow that it could never endanger the camp ground; because of the speed of the creek at this spot would take care of an abundant supply of water. We do not agree that there would be a large run off or PMF in this area because of the small drainage area.

Sincerely,

Bob Rice

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

FEB 28 1980

(7530)

Mr. Sidney Knutson, P.E.
Seattle District, Corps of Engrs.
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

As requested in your letter of February 8, 1980, we have reviewed the draft report of the Phase I inspection of Bell Lake Dam and have the following comments:

1. We agree with the recommendations in the report, with the correction of No. 11 to read 1/2 PMF.

2. Again, the hydrologic parameters used are excessive. To qualify a dam as "unsafe", based on this kind of hydrologic analysis, undermines the credibility of the report in general.

Sincerely,

R. W. LARSE
Regional Engineer

PHOTO 1 View Toward Dam, Dam Site on Left Just Beyond Ridge in Background

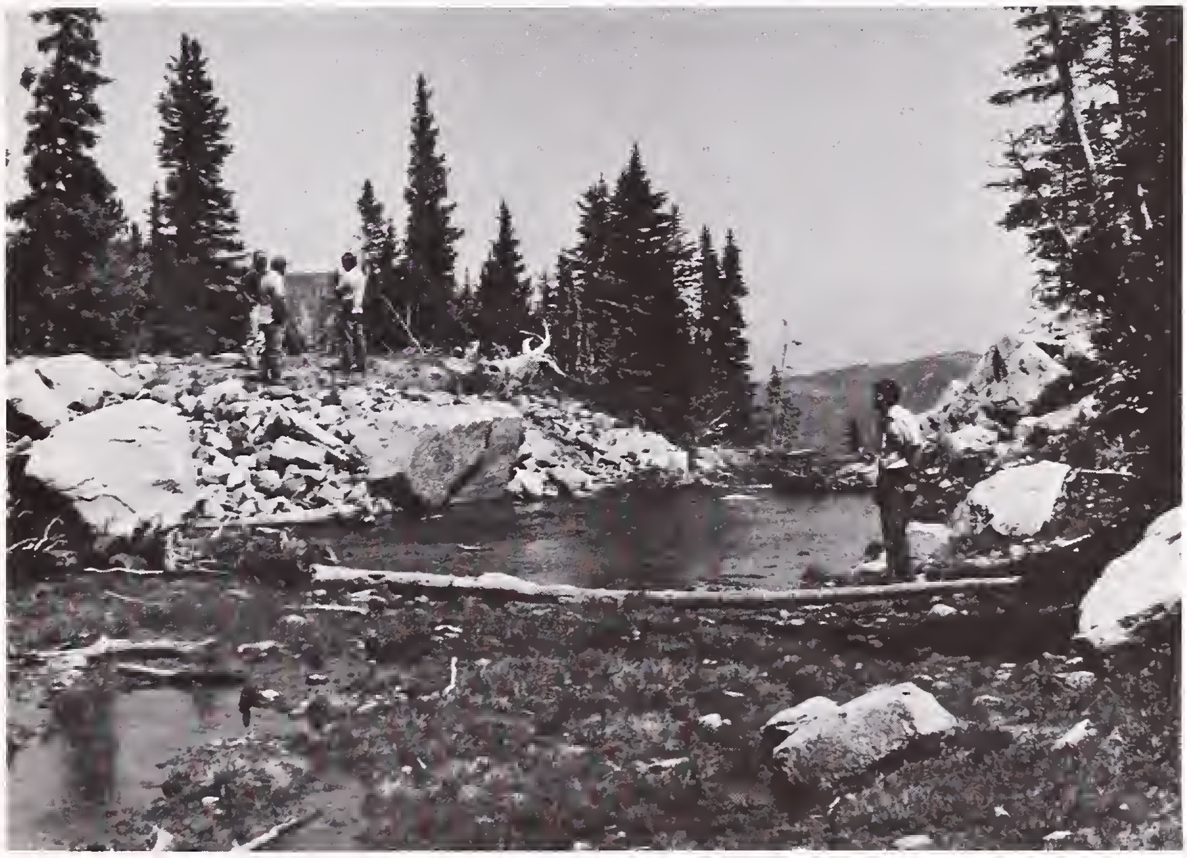


PHOTO 2 Spillway, Right Abutment

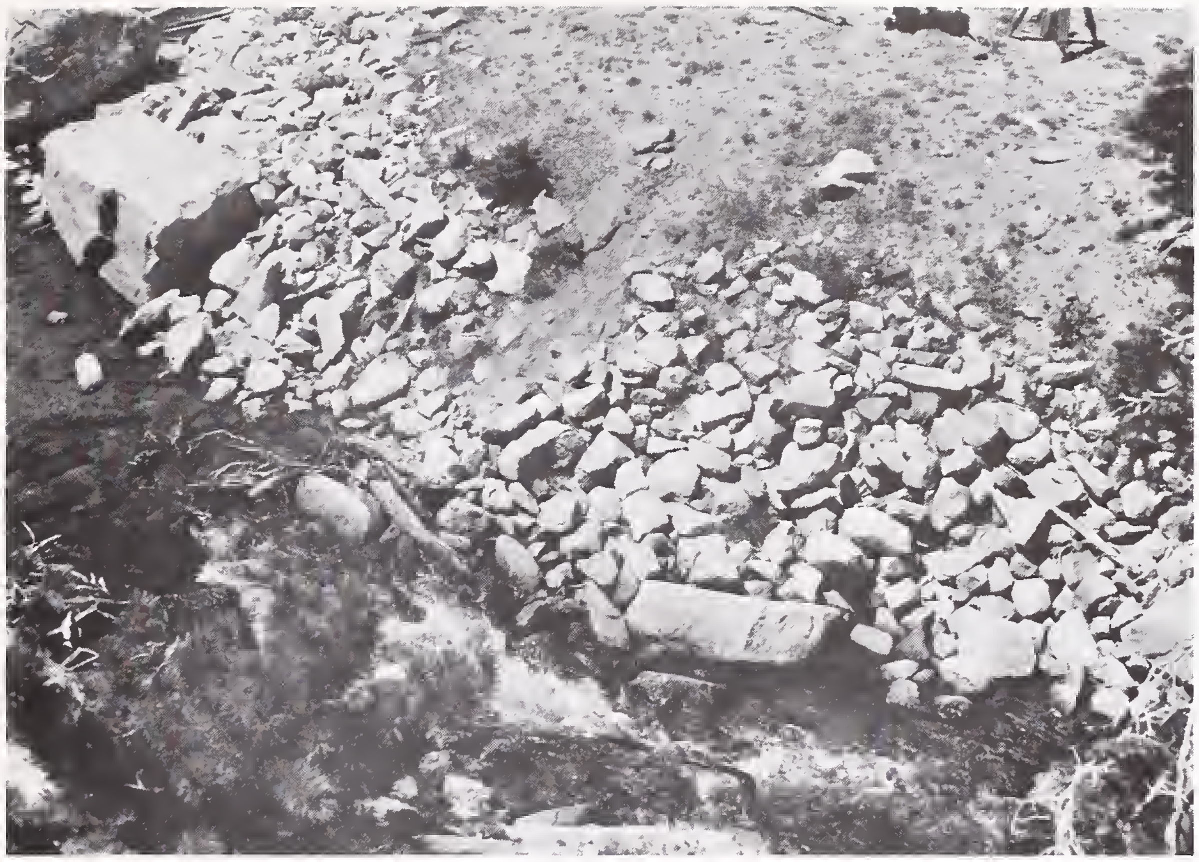


PHOTO 3 Riprap on Left Spillway Slope

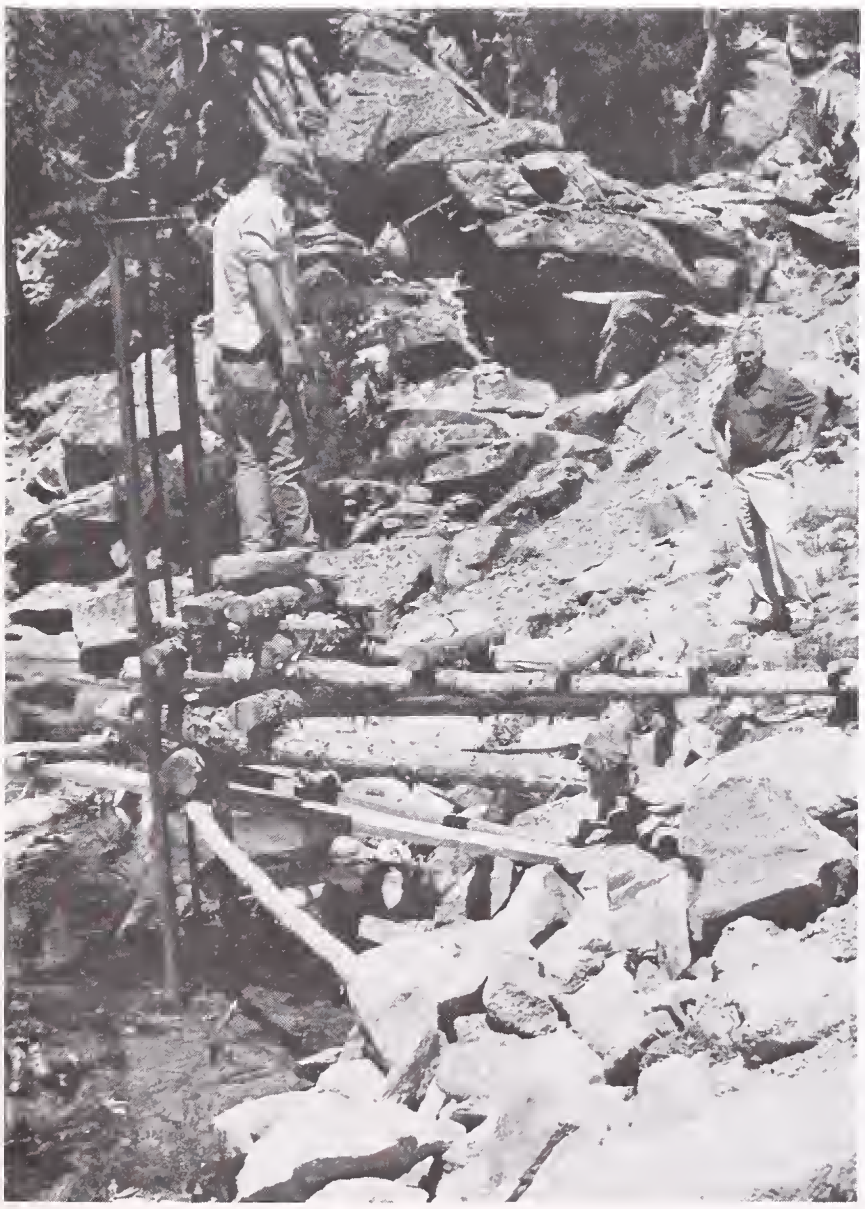


PHOTO 4 Outlet Works Slide Gate Control

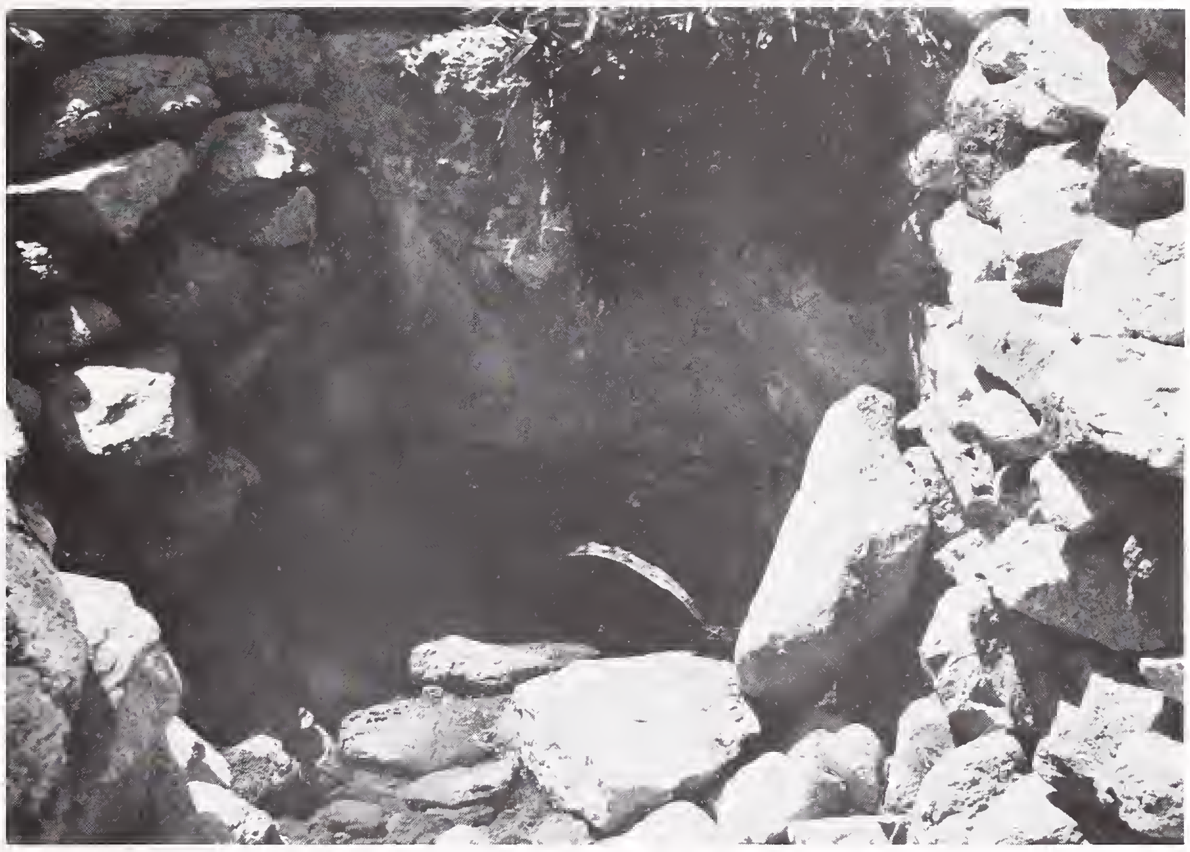


PHOTO 5 Outlet Works Conduit Exit

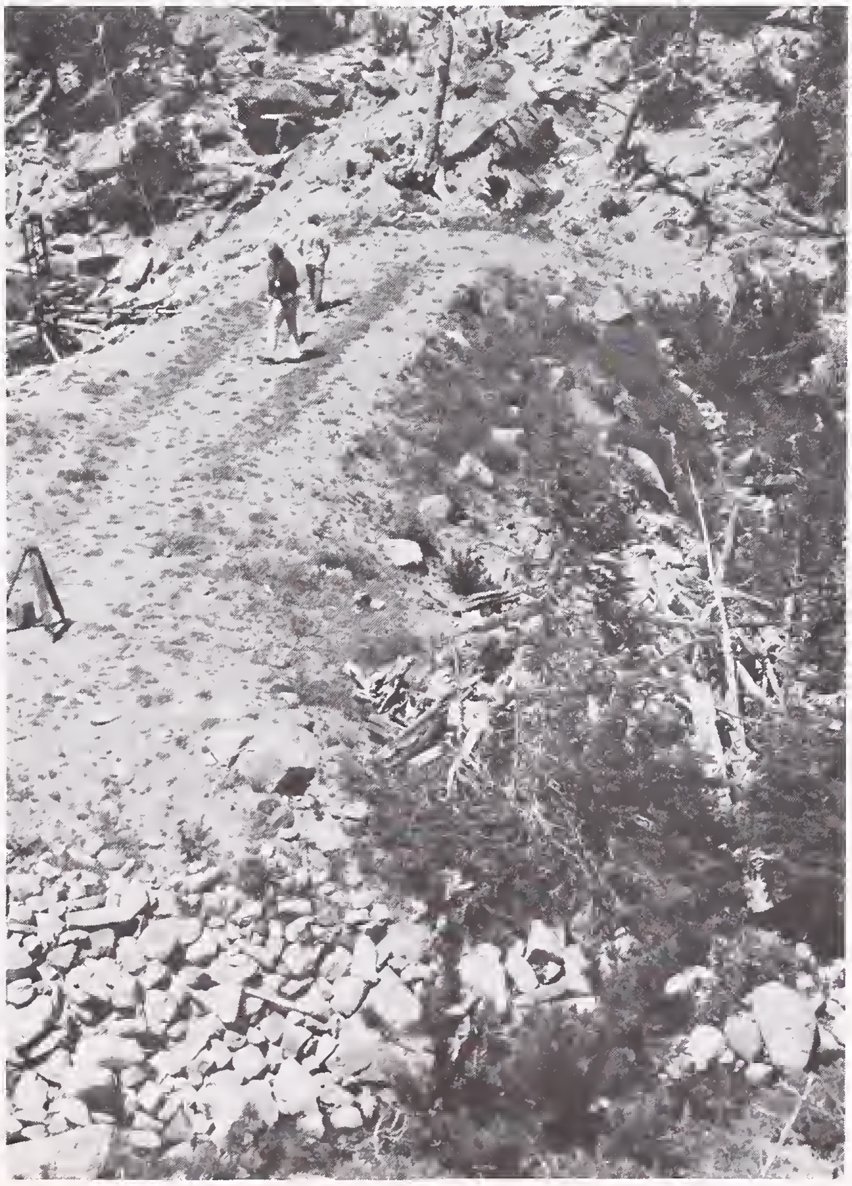


PHOTO 6 Downstream Slope

PHOTO 7   Upstream Slope

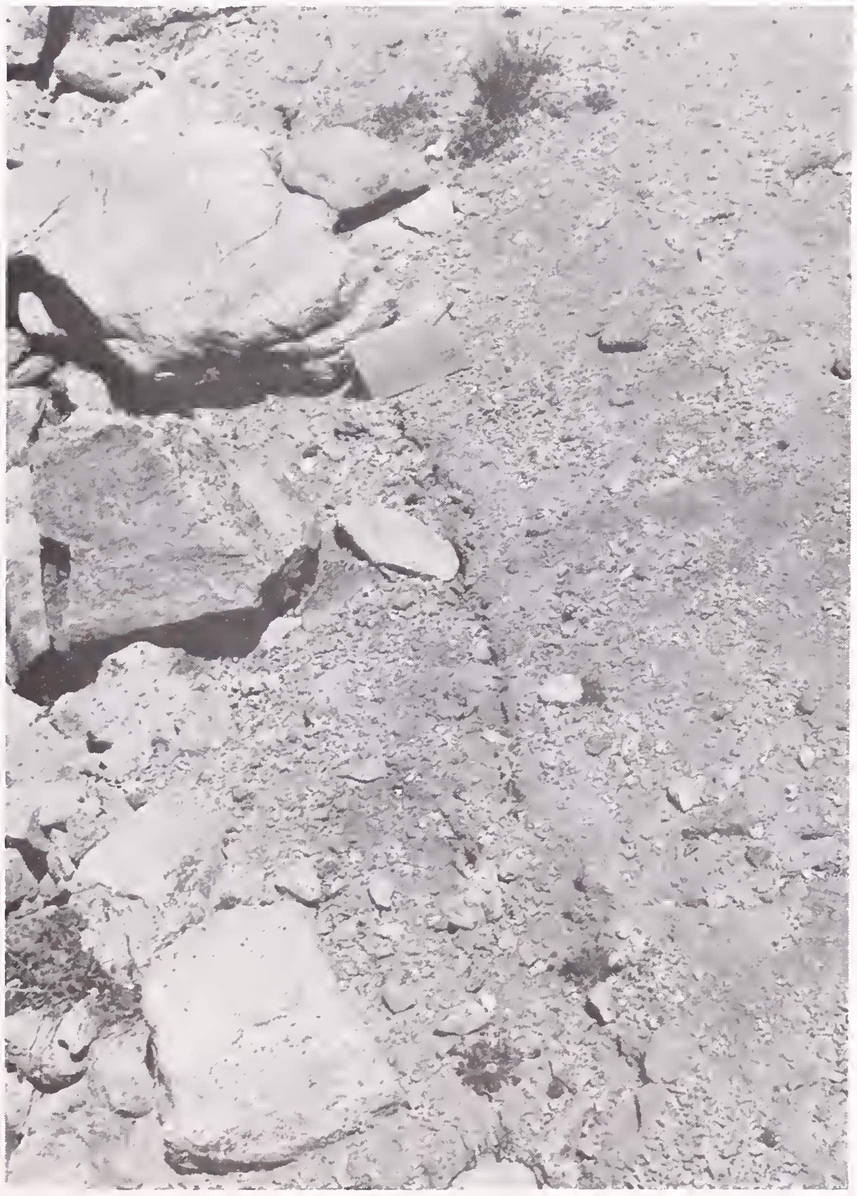
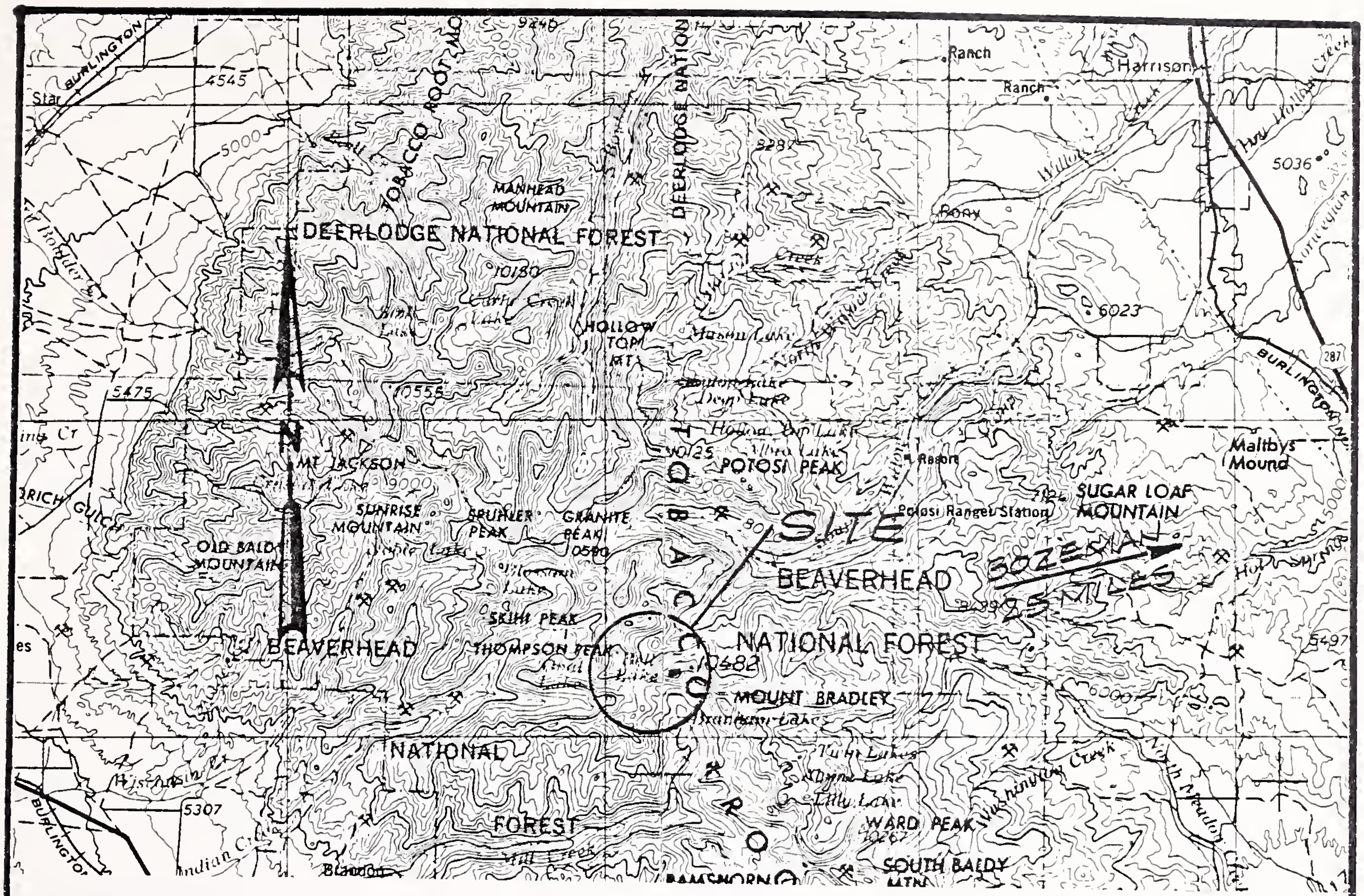
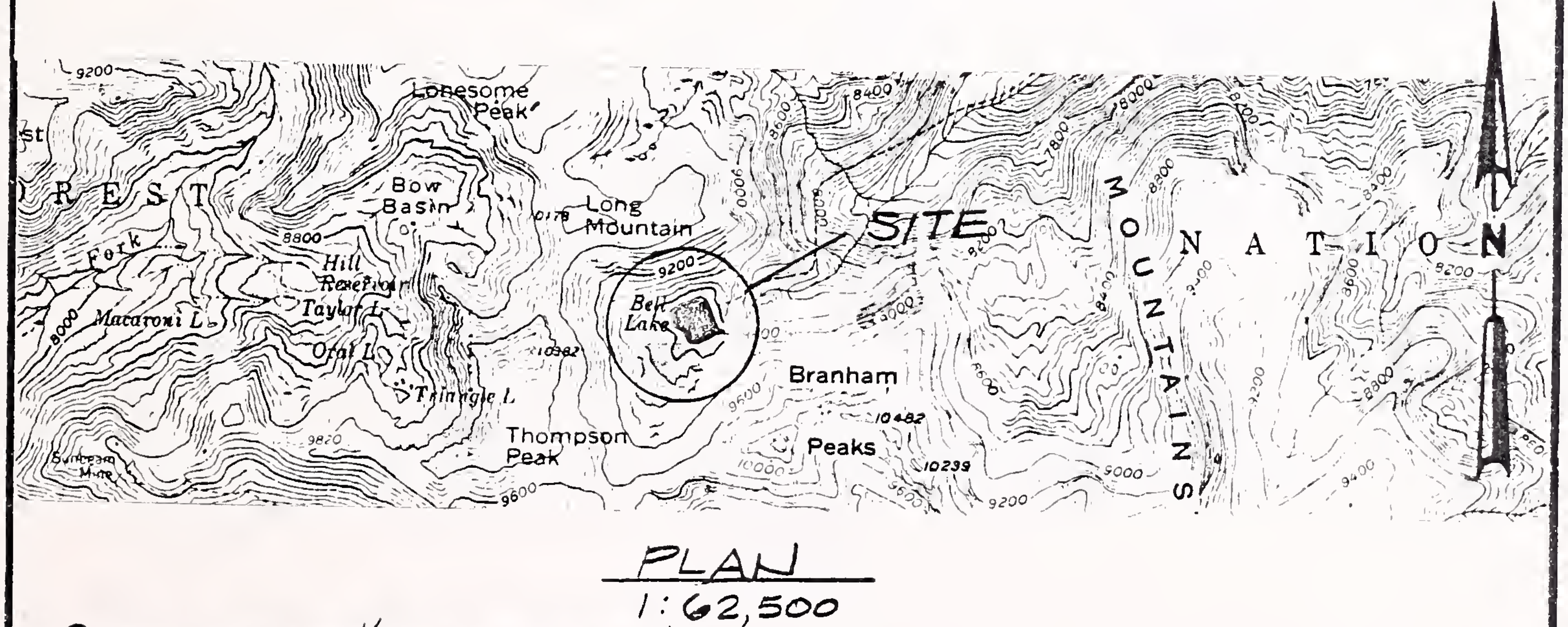


PHOTO 8   Longitudinal Crack
on Dam Crest Along
Upstream Edge



PLAN
1 : 250,000

0 5 10 MI.



PLAN
1 : 62,500

0 ½ 1 MI

PLATE 1

BELL LAKE DAM

VICINITY MAP

CH2M HILL

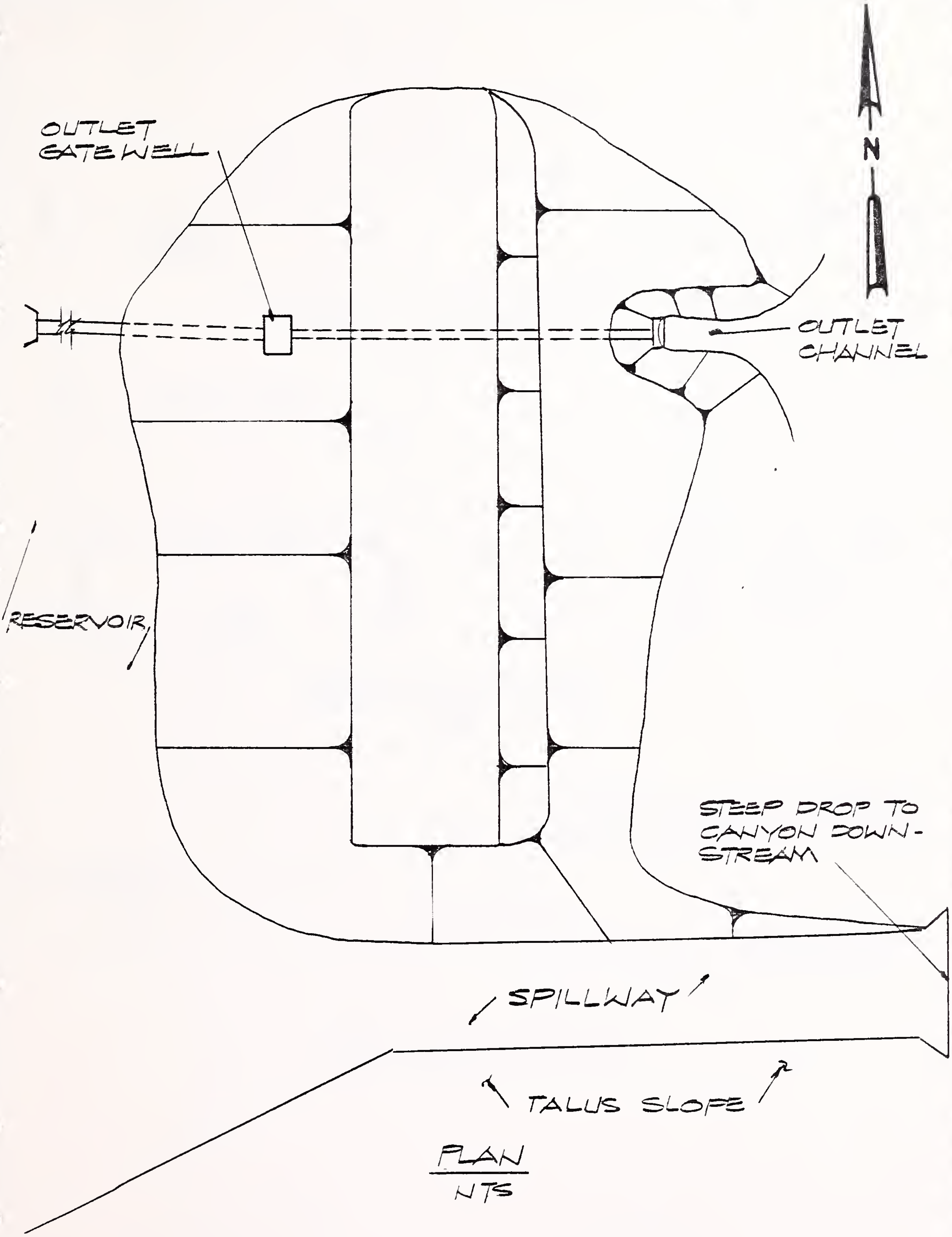
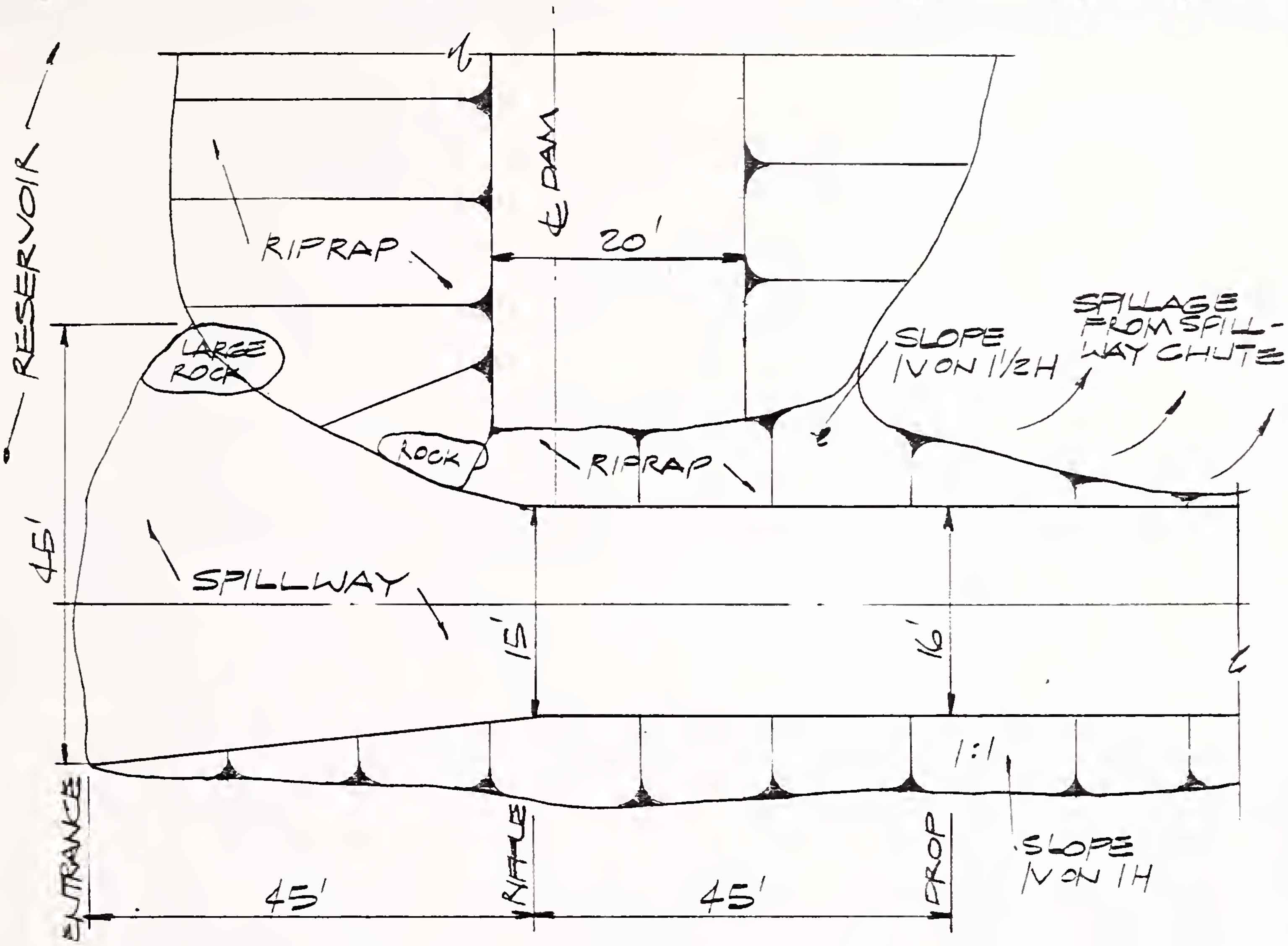


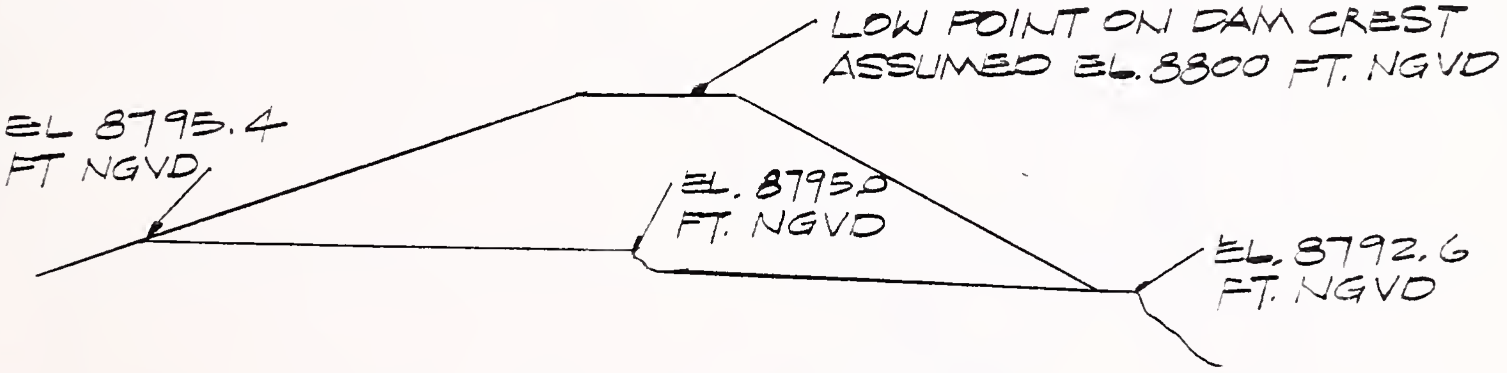
PLATE 2
BELL LAKE DAM
SITE PLAN

CH2M HILL



SPILLWAY PLAN

N.T.S.



SPILLWAY PROFILE

N.T.S.

PLATE 3

BELL LAKE DAM

SPILLWAY PLAN & PROFILE

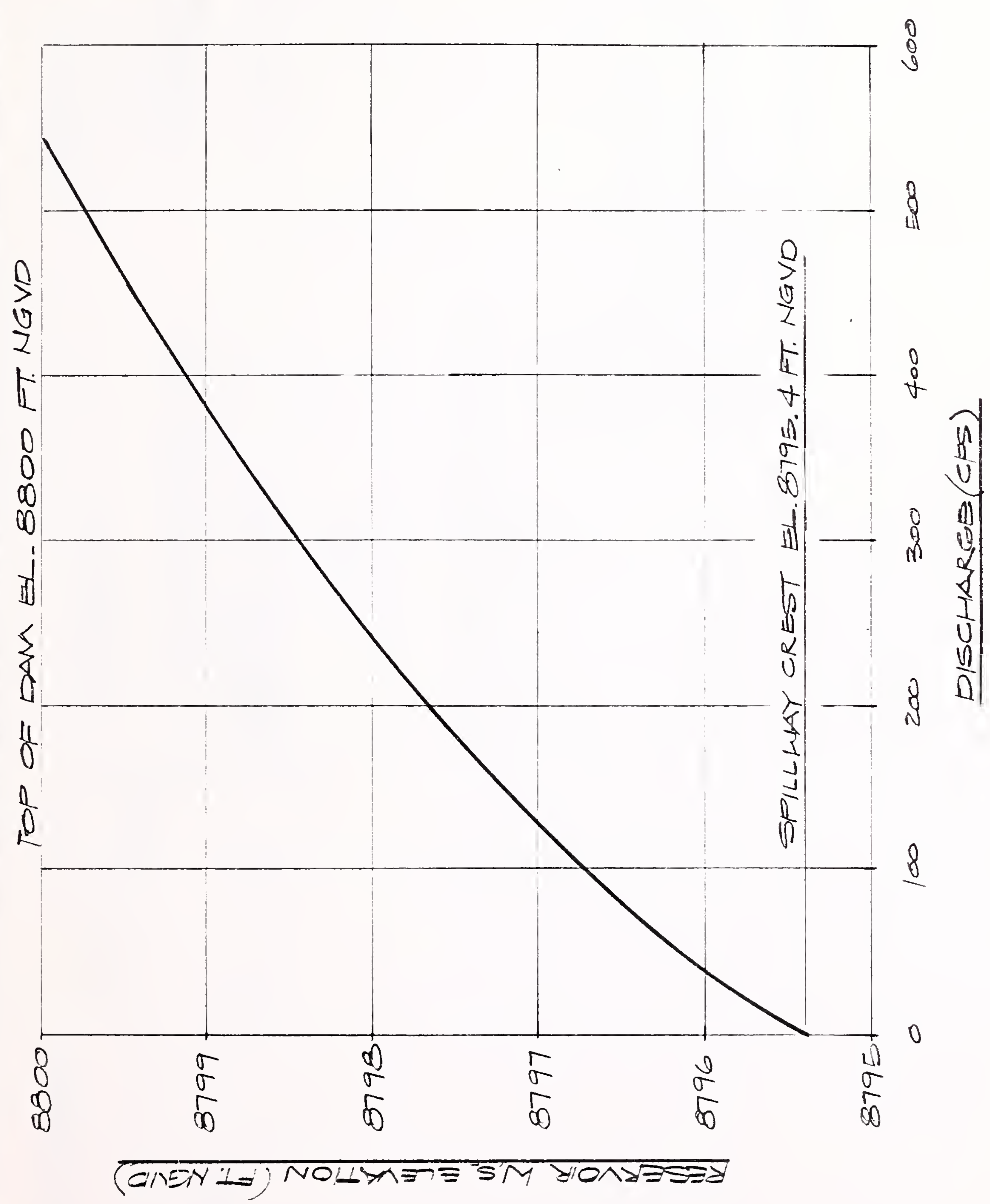
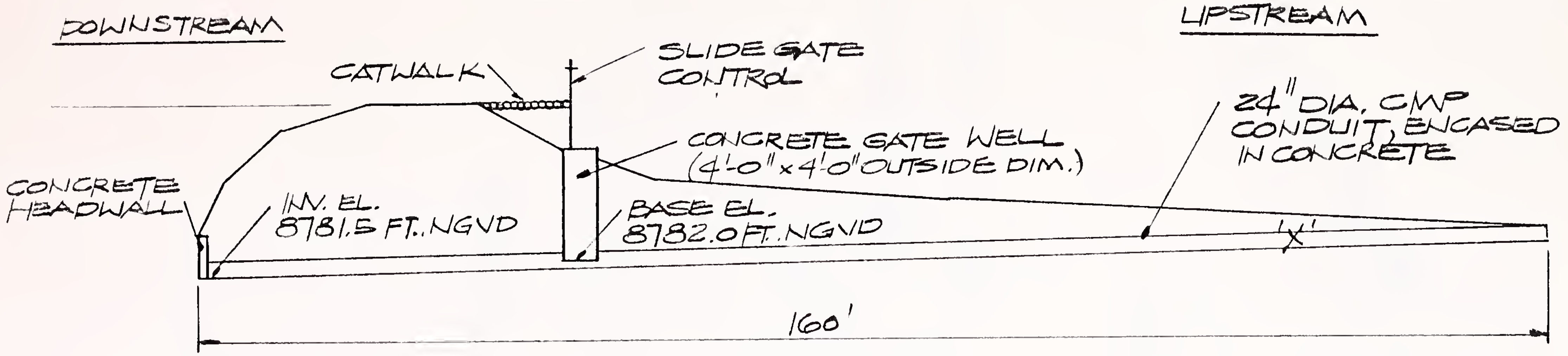


PLATE 4

BELL LAKE DAM

SPILLWAY RATING CURVE

CH2M HILL



OUTLET WORKS SECTION

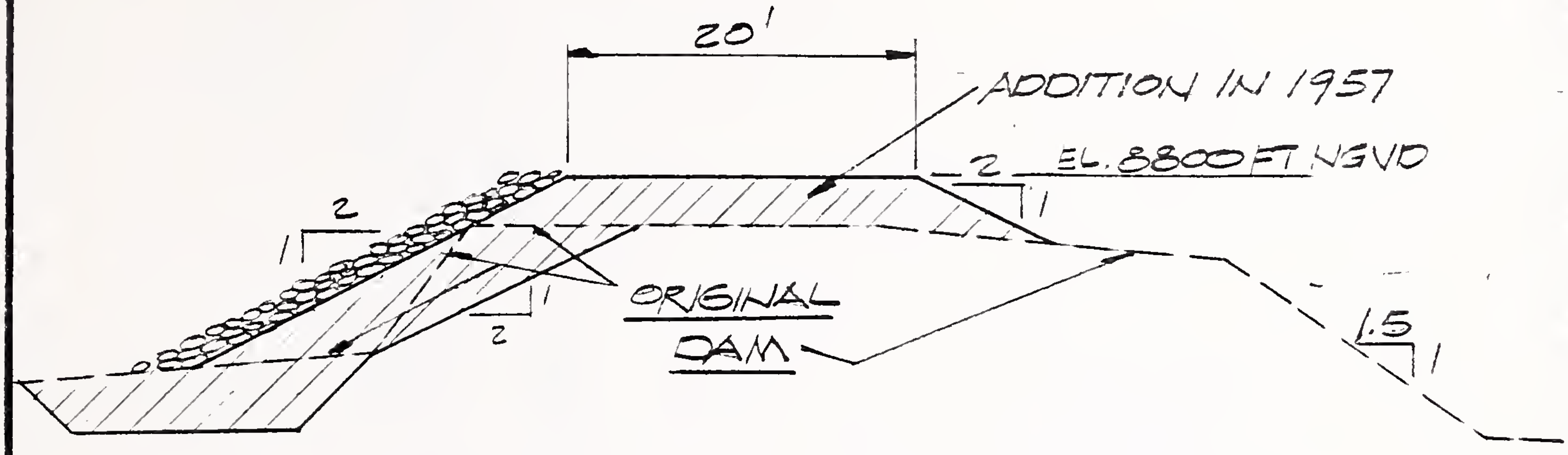
N.T.S.

NOTES:

1. ACCORDING TO PREVIOUS INSPECTION REPORTS PIPE SEAM BROKEN AT 'X' WATER IS GOING INTO BROKEN SEAM. PIPE EXTENDS 35' TO 40' BEYOND SEAM.
2. BELL LAKE DAM SURVEYED BY J.B. KNAEBEL & G. WARD, OCT. 9, 1962

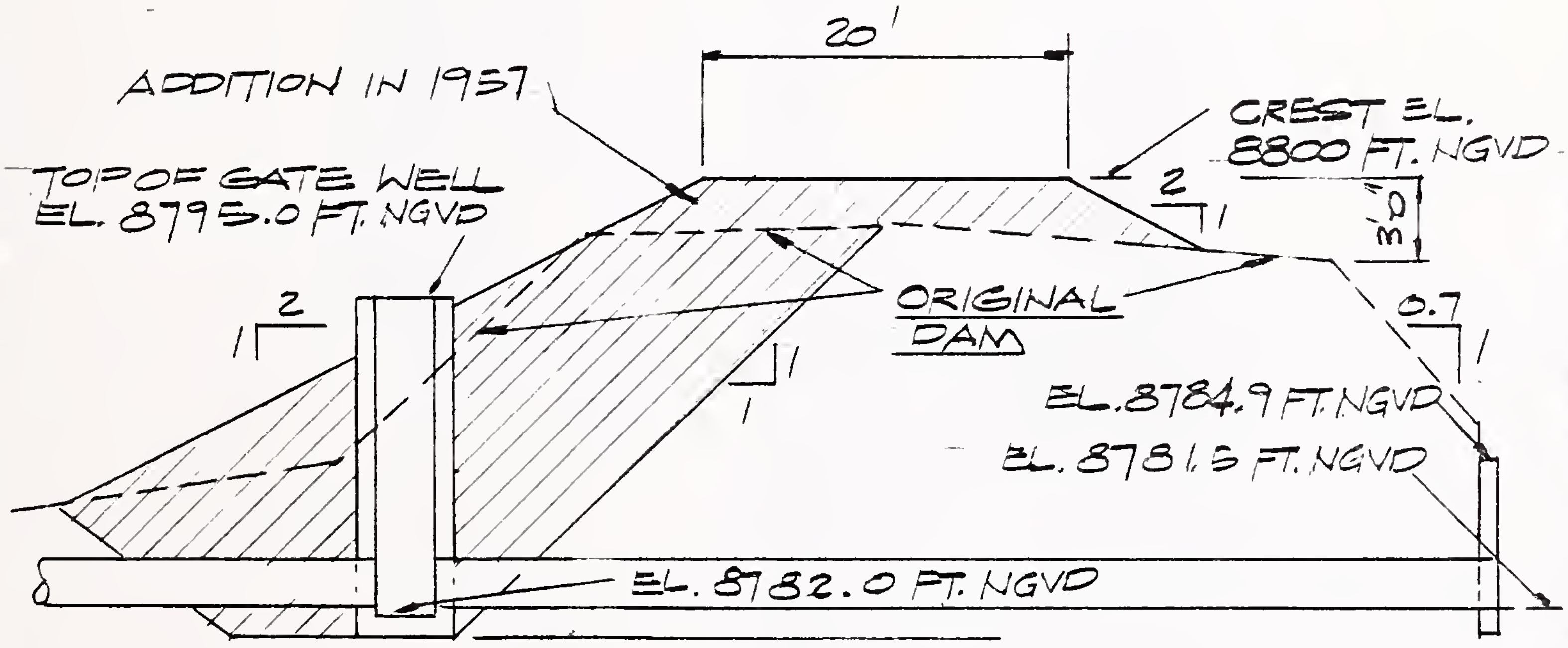
PLATE 5
BELL LAKE DAM
OUTLET WORKS SECTION

CH2M HILL



TYPICAL DAM SECTION

N.T.S.



SECTION THROUGH OUTLET

N.T.S.

NOTES:

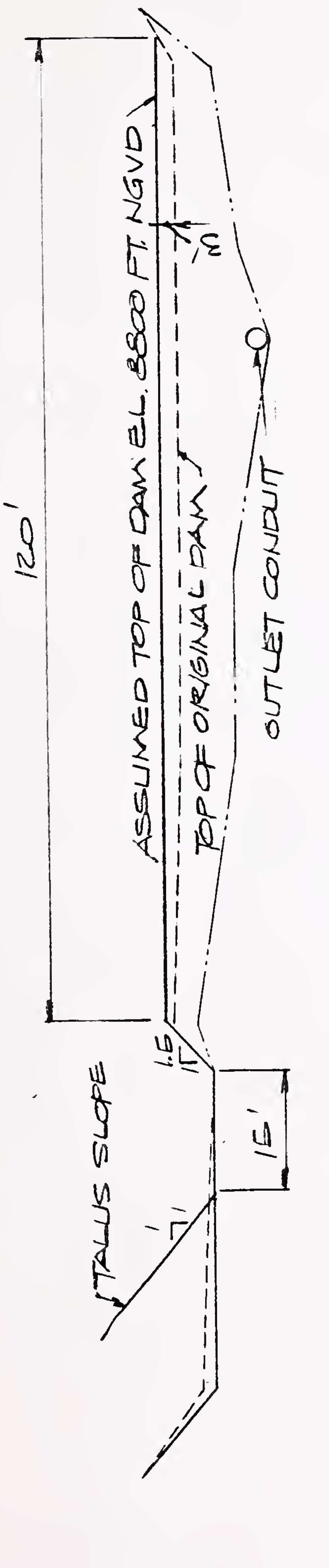
1. REPAIRS TO BELL LAKE DAM BY U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE, 8/18/56.
2. ALL ELEVATIONS MEASURED DURING INSPECTION, ASSUMED DAM CREST EL. 8800 FT. NGVD

PLATE 6

BELL LAKE DAM

DAM EMBANKMENT SECTIONS

CH2M HILL



PROFILE OF DAM & SPILLWAY

N.T.S.

NOTE:
REPAIRS TO BELL DAM
BY U.S. DEPARTMENT OF
AGRICULTURE SOIL CONSERVATION
SERVICE, 8/18/56

PLATE 7

BELL LAKE DAM

PROFILE DAM & SPILLWAY

CH2M HILL